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ENDEMIC MALARIA OF THE JEYPORE HILL TRACTS OF THE MADRAS PRESIDENCY

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MAJOR E. L. PERRY, I.M.S.

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I.—DESCRIPTION OF THE AREA INVESTIGATED. PHYSICAL FEATURES, POPULATION AND CLIMATE.

Physical features.

The area investigated is included in the district of Vizagapatam in the Madras Presidency and is situated on the East Coast of India about midway between the ports of Calcutta and Madras.

The coast line of India here runs from north-east to south-west. Roughly parallel to the coast and at a distance inland of some 40 to 50 miles rises somewhat abruptly the low range of mountains known as the Eastern Ghats. Between the coast and the ghats is a fertile strip of plains sloping at an easy gradient from sea-level to a level of about 500 feet above sea-level at the foot of the hills, but scattered over this plain or numerous isolated hills sometimes rising to a considerable height. The soil of the plains is formed of laterite and is everywhere of a conspicuous red colour.

This coastal plain supports a highly prosperous Telugu-speaking population whose average density is 490 persons to the square mile. The average rainfall is 41 inches much of which falls during September, October and November, i.e., in the season of the north-east monsoon, for the tract in question is largely sheltered from the south-west monsoon which prevails from June to September and is the chief source of rainfall for the greater part

of India. Inland towards the hills, in the neighbourhood of the rivers and in the country irrigated from the numerous tanks periodically filled by streams from the hills, much rice is grown. In the district generally the chief crops grown, in their order of acreage, are rice, the staple food of the better classes, *cambu*, the staple food of the lower classes, oilseeds, *ragi*, and *cholam*. Of the net area cropped nearly half is cropped twice during the year.

Excepting in certain somewhat isolated foci the population of these plains is in a remarkable measure malaria free.

The thickly jungle clad slopes of the Eastern Ghats rise somewhat abruptly from the plains, several of the peaks which overlook the plains of Vizagapatam attaining an altitude of over 5,000 feet. The highest level of the hill tracts is reached within a few miles of the plains and from thence the ground slopes away inland towards the Gōdāvari valley and the Central Provinces. For a distance of 40 to 50 miles westwards from the edge of the ghats is what is commonly known as the 3,000 foot plateau. This is a great undulating table and which maintains a more or less uniform level of about 3,000 feet above sea-level, but from which arise innumerable rounded hills of varying height. Between the hills lie flat-bottomed level valleys, occasionally several miles in width, and traversed everywhere by streams, along the course of which there is abundant rice cultivation. Many of the hills are covered with dense jungle whilst others have been almost denuded of such. Away from the vicinity of the streams dry crops, mainly ragi and oilseed, are extensively grown.

The main physical feature from a malarial point of view is the enormous number of little streams flowing along an easy gradient. A small hill, not half a mile in diameter at the base, will sometimes give rise to 9 or 10 separate streamlets.

On the western edge of the higher plateau there occurs an abrupt descent of about 1,000 feet which leads on to a lower plateau, known as the 2,000 foot plateau, a more or less unbroken level plain stretching away with a gentle slope to the borders of the Central Provinces.

Though mainly covered with vast expanses of jungle, largely constituted of sâl, this lower plateau has in parts been extensively cleared and cultivated with rice. But whereas on the 3,000 foot plateau, land, fed by perennial streams, is in many places cropped for rice thrice during the year, on the 2,000 foot plateau the rice crop is directly dependent on the actual monsoon rainfall and the cultivation of rice is confined strictly to the monsoon season.

The 2,000 foot plateau, owing to the absence of the innumerable hills which constitute such a feature of the upper plateau, is nothing like so extensively cut up by small perennial streams. The streams and rivers which contain water throughout the year are, in comparison with those of the upper plateau, few and far between and meander through the plain in deeply cut sandy beds. Their smaller tributaries for the most part only carry water during the monsoon.

When the 2,000 foot plateau is followed in a south-westerly direction about 20 miles from Jeypore town, another less abrupt

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descent, of about 1,000 feet, leads on to a yet lower plateau which slopes down to the Gōdāvari. As far as I have observed it and traversed it there did not appear to be any striking difference between this lowest plateau and the 2,000 foot one, and it is probable that, as far as malāria is concerned, much that applies to the 2,000 foot plateau also applies to this.

In every place that I visited, on all of these three plateaus, the soil appeared to be largely composed of the products of disintegration of red laterite rock. This soil which has a great capacity for absorbing water is most unfavourable to the formation of puddles. On the upper plateau, even though rain might have been falling continuously for three or four days in succession, within 24 hours of the cessation of rain the roads and fields were dry. Borrow pits never retained water but dried immediately the rain ceased. If, however, the laterite rocks, which enter so largely into the formation of the hills on the 3,000 foot plateau, have great powers of absorbing water, they also, by reason that they husband the great rainfall of the monsoon months and part with it slowly during the less rainy months, constitute a factor most favourable to the long continuance of the flow of water in the smaller streams.

On the 3,000 foot plateau village tanks are not to be seen, all water being obtained from streams. On the 2,000 foot plateau, however, owing to the great difference of the water system, every village and town has at least one tank. These are large open stretches of shallow water usually with an abundant growth of weeds and water-lilies. At large towns like Jeypore and Malkanagiri the tanks are of great size. It is of interest to note that the village of Jayanagar, one of the villages where a spleen rate much below the average was found, was situated immediately upon the swampy border of the great Jeypore tank.

At Malkanagiri at the end of January with a hot steamy sweltering atmosphere, no anopheles larvae were to be found in the tank, nor were any to be found in the swampy ground below its bund. The tank at this time swarmed with fish, both large and small.

Population.

The average density of population in the Jeypore Hills is 70 persons to the square mile; but the density varies greatly in the different taluks :—

3,000 foot plateau ...	Koraput ...	110 per square mile.
	Padwa ...	47 ,, ,, ,,
	Pottangi ...	117 ,, ,, ,,
2,000 foot plateau ...	Jeypore ...	132 ,, ,, ,,
	Nowrangapur ...	48 ,, ,, ,,
1,000 foot plateau ...	Malkanagiri ...	15 ,, ,, ,,

In passing from the plains of Vizagapatam into the Jeypore Hills we pass abruptly from a region practically free from malaria into one that is notorious as the most malarious in Southern India. We pass equally suddenly from amongst races with a highly developed civilization into a country almost exclusively peopled by tribes of primitive savages. It was amongst these very tribes that

the appalling rite of the Meriah or human sacrifice was suppressed as late as the seventies of last century.

Concerning the history of the tribes inhabiting the Jeypore Hills we have no direct information. While most of them speak dialects belonging to the Dravidian family of languages, there is one large tribe, the Gadabas, differentiated from their neighbours by many striking characteristics in their customs, clothing, ornamentation, dwellings, etc., who speak a Munda or Kolarian dialect. These two languages, the Munda and Dravidian, are, according to Dr. Grierson(1), in no way connected.

Notwithstanding the absence of all direct evidence as to the history of the tribes we have to deal with in the Jeypore Hills, it must be admitted that these tribes are of very great antiquity and have been occupying the jungles they now live in from a very remote age. If civilization in India were a phenomenon of recent date there might be nothing remarkable in the survival of such primitive tribes and in the degree to which they have preserved their identity. But high degrees of culture were attained in most regions of India some thousands of years ago. Whilst Buddhism has spread throughout India and again receded whilst Muhamadanism has become established from the Trans-Indus to the Deccan, these tribes have preserved the most primitive animistic faiths and the most primitive customs and characteristics. Were India a country sparsely populated even, one might understand their preservation, but India is a country very densely populated. Moreover much of the country in the Jeypore Hills, with its abundant rainfall, is of very great agricultural value. Much of it lies within less than 100 miles of the sea coast. Nor is it merely owing to any physical inaccessibility of the hills which they occupy that they have been able to withstand the intrusion or invasion of more civilized races. Much of their country presents no great physical obstacle to an invader, for a mountainous country it is exceedingly easy to enter and to traverse. The truth almost certainly must be that were it not for the great virulence of the malaria which these people harbour and the ample anopheline fauna of their jungles, such tribes would have been absorbed into the great Dravidian or Aryan civilizations of India and practically lost sight of long ago.

The Gadabas, Khonds, and Porojas are the great aboriginal tribes occupying the upper plateau. The Bhumias, Bhottadas, Omanaitos, and Gonds form the bulk of the aborigines of the lower plateaus.

The upper castes of the Jeypore country are the Ronas and Paiks, terms which may be taken as almost synonymous. These are the descendants of the matchlock men of the old rajas who were granted land in return for services. They are Oriya speaking people and more or less immigrants to the country. The Ronas are not of very long standing in Jeypore (Thurston)(2).

The Sundis, the Oriya toddy distillers who hold all the excise licences, also regard themselves as highly superior to the humble but thirsty aborigines. Intellectually and economically they, of course, are superior. Like the Ronas and Paiks they are a more or less immigrant caste.

All the Telugus living in the villages of the Jeypore Hills are more or less recent immigrants from the plains of Vizagapatam.

The lower castes met with throughout the Jeypore Hills are chiefly Dombos, in lesser numbers Ghasis, whilst colonies of Rellis are met with in a few villages both on the upper and lower plateau. By the Khonds, Gadabas, and Porojas the Dombos are treated as utter outcastes. Though there are many large villages which are mainly Dombo villages, yet the majority of the Dombos form colonies in the villages of other tribes and commonly have a separate location on the outskirts of the village. Intellectually they are markedly superior to the aboriginal tribes but in musculature and in physical capacity to undertake heavy labour they are markedly inferior. I am told by the missionaries that a Dombo usually feels more ill during an attack of fever than would a Gadaba, a Khond, or a Poroja. When we come to the consideration of the spleen rates amongst the various tribes we shall see that the spleen rate of the Dombos differs markedly from that of the Gadabas, Khonds, and Porojas and tends in a measure to approach that of the immigrant races.

The Rellis are a low caste of immigrants from the plains of Vizagapatam. Many of them came into the country after the great famine of 1876. The Ghasis are an equally low Oriya-speaking caste. As far as one can gather they are not such recent immigrants as the Rellis.

The Malis are Oriya speaking, prosperous, and well-to-do cultivators. They have been granted lands by the raja mainly in places where streams suitable for their class of cultivation (sugar-cane and vegetables) issue from the sides of the hills.

The Kapus examined by me were living in the neighbourhood of Araku on the upper plateau. They are a Telugu-speaking cultivator caste who have immigrated from the plains of Vizagapatam, though they maintain that they have long been settled on the land they now occupy. The majority of the Khonda Doras whom I saw were living in the same villages as the Kapus. The Khonda Doras speak Telugu but are said by Thurston to have originally spoken a dialect of Khond and to have acquired Telugu from contact with the people of the plains.

Climate.

On the 3,000 foot plateau the temperature for the greater part of the year is cool and pleasant and in the months of January and February the nights are often excessively cold, the thermometer falling close to the freezing point. In the months of April and May before the onset of the rains the day temperature in the shade rises sometimes to 97 or 98° Fahr. The nights, however, are always pleasant and cool. When the rains commence in June the temperature falls and throughout the rains the day temperatures are about 70 to 75° and the night temperature about 65°.

On the 2,000 foot plateau the temperatures are slightly higher. After the cessation of the rains the day temperatures tend to rise again but by November the nights are becoming very chilly.

It will be seen that in the Jeypore Hills with the exception of the cold nights in December, January, and February there is nothing in the temparature unfavourable to the carriage of malaria by anophelines during the greater part of the year. But on the other hand the temperature conditions of the plains, over the greater part of which there is practically no malaria, are in this respect even more favourable.

In dealing, however, with the relationship of temperature conditions to the amount of endemic malaria not alone the question of the development of the parasite in anophelines but also the equally important question of the development and carriage in the human host must be considered. A climate like that of Jeypore, although for the greater part of the year mild, is at times cold, wet, and windy, and amongst a people ill-clad and more or less at the mercy of the elements, this may be highly favourable to the production amongst them of relapses and the long sustained life of the parasite in their circulation.

As we pass inland from the coast not only does the rainfall increase but the influence of the south-west Monsoon (which blows from early summer till the end of September) increases, whilst that of the north-east Monsoon (which blows during October to December) decreases.

The actual amount of the rainfall has but little to do with determining the malariousness of any place in the Jeypore Hills. What is important is what happens to the rain after it has fallen. Small hills and jungle hold it up and part with it slowly favouring the breeding of anophelines. On open well cultivated rice land, drained by deeply cut rivers, the water lies deep on the rice fields during the continuance of the rainy season and various forms of aquatic life unfavourable to anopheline larvæ a bound in it, but at the end of the rainy season it is rapidly absorbed by the soil and flows, largely underground, to join the main streams.

II.—Malaria in the Neighbourhood of Vizagapatam Town.

The observations relating to malaria on the coast were made during January 1911.

In and around Waltair (residential portion of Vizagapatam) and in the adjacent parts of Vizagapatam and near all the neighbouring villages visited anopheles larvæ were readily found. There was plenty of water about, and in all suitable places which were searched larvæ were found. Probably there was more water about at this time than was usual in January owing to the rainfall of 1910 having been in excess. But judging from the amount of irrigation that was going on it was obvious that there must usually be an abundant supply of breeding places.

The following species of anophelines were bred out from the larvæ :—

A. culicifacies, *A. fuliginosus*, *A. stephensi*, *A. maculipalpis* *A. rossi*, *A. sinensis*. Of the above six species the four which are named first are known to be carriers of malaria in nature.

In the village in Lawson's Bay just north of Waltair I examined 30 children but none of them had enlargement of the spleen. On the sea front of Vizagapatam town in the Jalarupet quarter there is located a large colony of fisher people. The place swarms with children as cheerful, healthy, and sturdy as one could wish to see. I examined 120 of these and found only one spleen size 1 and one spleen size 2. In Chachaidapet, a continuation of Jalarupet, mainly occupied by vegetable sellers, I examined 65 children and found one spleen size 1 and one spleen size 2. At Burujupet in the heart of the town and where the milk-sellers mainly reside I examined 102 children and found none with enlargement of the spleen. In the Durga Veedi and Kancha Veedi quarters I examined 100 children and found two spleens size 2.

Thus in the main part of Vizagapatam town the spleen rate is well under 3 per cent.

Near the harbour the case is different.

Between the main portion of Vizagapatam town and the channel connecting the sea with the backwater is an abrupt, isolated ridge of hill. Between this ridge of hill and the channel there is a fisher village which ends near the Coromandel Company's offices. In this village I examined 50 children and found 13 (26 per cent) with enlarged spleens. (One size 1, three size 2, seven size 3, and two size 4.) On the Vizagapatam side of the above-mentioned hill in the Abboosarang quarter I examined 120 children and found 22 (18 per cent) with enlarged spleens. (Five size 1, nine size 2, seven size 3, and one size 4.)

On the far side of the channel a much worse condition of things is met with.

By crossing the channel to the south side of the harbour the road to Anakāpalle is reached. Along this road there are three villages within 1½ miles of the harbour. These villages which are shown on the map had spleen rates as follows:—

> Tipparavupalam. 66 children. Spleen rate 65 per cent.
> (8 size 1. 17 size 2. 13 size 3. 5 size 4.)
> Chintalupalam. 52 children. Spleen rate 70 per cent.
> (9 size 1. 10 size 2. 11 size 3. 6 size 4.)
> Malakapuram. 68 children. Spleen rate 36 per cent.
> (12 size 1. 7 size 2. 6 size 3.)

I was much struck with the condition of these villages. The people complained greatly of the fever from which they suffered and pointed out to me patients, with fever on them, lying about in verandahs. I am inclined to conclude that of recent years malaria must have been growing increasingly severe in these villages. There are also several deserted bungalows on the south side of the harbour. The matter is one which calls for careful investigation.

A point of some interest is that, a few years ago, a large number of the fisher people who live in the Jalarupet quarter were, for sanitary reasons, removed to the south side of the harbour where a new site for a village was allotted to them. They rapidly developed such an intense decree of malaria and the mortality

amongst them became so alarming that the Municipal Committee of Vizagapatam were obliged to allow them to return to their original quarters. In the event of extensive harbour works being undertaken at Vizagapatam, it will be of vital importance to be most circumspect in the matter of the location of cooly encampments.

There are two classical instances of towns on the East Coast of Madras which were at one time healthy but subsequently became so excessively malarious as to be in a large measure abandoned. I refer to Ganjām and Ennur.

Enough has been said to indicate that the conditions relating to malaria in the neighbourhood of Vizagapatam town are matters of great public and scientific importance.

A visit was made to Bimlipatam, a town on the coast some 18 miles north of Vizagapatam. Here as at Waltair anopheline larvæ were found with ease in considerable numbers. They could be found also in water close to the sea-shore. The species present were not determined. 112 children were examined but no enlargement of the spleen was detected.

III.—MALARIA IN THE HILL TRACTS. ANOPHELES.

The Upper Plateau.

The wide distribution and intensity of malaria has earned for this region an unpleasant reputation. Among both European and Indian immigrants blackwater fever is of frequent occurrence.

Yet so little does the general appearance of the 3,000 foot plateau suggest malariousness that when the town of Jeypore, which is on the 2,000 foot plateau, proved so malarious, a site for the head-quarters of the district was chosen at Koraput on the upper plateau under the mistaken impression that it must be far healthier. This expectation was doomed to end in grievous disappointment and disillusionment. In the old administrative reports of the Jeypore Agency stress is laid on the excessive malariousness of Jeypore town itself. It was stated that to stay in the station for but one night was sufficient to contract fever. The dense jungle was described as coming up to the very gates of the compounds. It was confidently hoped that Koraput at so much higher an altitude and so extensively cleared of jungle would be far less malarious.

One can readily sympathize with those who fell into this error. Here is a country, in large part cleared of jungle to the verge of desolation, of a configuration allowing of free and ample drainage in every direction, with a dry wholesome soil, with rice grown in the immediate vicinity of the streams but elsewhere dry crops or grass, with grass and jungle so dry that in spring it is annually burnt throughout the country, possessed of a cool and pleasant climate and peopled with cheerful, sturdy, and vigorous aborigines.

It was not unnatural that instead of clearing the neighbourhood of Jeypore of jungle they elected to move to Koraput where for miles around the jungle was already cleared. They moved from out of the frying-pan into the fire, for although they left the jungle behind they encountered a yet more deadly source of malaria in the innocent looking hill streams of the upper plateau. It is natural to suspect dense tropical jungle and large swampy tanks of connexion with malaria, but hill streams of a type familiar to us in Devonshire or Wales have not yet been popularly associated with malaria.

On arriving at Koraput, early in the year, I was myself deceived by the appearance of the country. It led me to expect that not till later in the season should I obtain at Koraput sufficient anopheline material for study. I thought that by going down to the lower plateau with its great tracts of jungle I might find plenty of anopheles and had arranged to go there. But on searching the villages I found ample anopheline material. At the end of January I descended to the lower plateau and found to my surprise that, at that season of the year, instead of adult anopheles being more abundant than on the upper plateau they were (in villages away from the actual foot of the hills) found with the greatest difficulty, whilst in some villages prolonged search failed to reveal a single one.

Although by searching cowsheds and native dwellings on the upper plateau, adult anopheles could, as a rule, be found in considerable numbers, this tract is an example of a country in which anophelines are abundant enough when so looked for, but are by no means very much in evidence to casual observation. In the Government bungalow at Koraput anopheles were by no means common. Anopheles (*A. maculipennis*) were far more common in the bedrooms of the house occupied by the writer when working at Sir Eustace Gurney's Freshwater Zoological Laboratory at Sutton Broad, Norfolk, than they ever were in the bungalows at Koraput or Dholiambo. The small extent to which anophelines were apparent to casual observation on the plateau was phenomenal when compared with the conditions in the north of India.

A very noticeable exception to the usual rule was observed on three nights in the middle of November. I was camping near rice fields which were being cut, and about an hour after dark anophelines in considerable numbers commenced coming into the tent. I often camped near water and rice fields, but on no other occasion did anophelines enter the tent in any numbers.

During the rains on the upper plateau *A. culicifacies* were very readily found resting near the roots of thick bushes where they were sheltered from the incessant drizzling rain.

Culicines were rarely taken on the 3,000 foot plateau. They never constituted as much as 3 per cent of the total catch in villages in any month.

In contradistinction to the comparative abundance of adult anopheles in cowsheds, etc., larvæ were at many times difficult to find. The ease or difficulty with which they were found had little relation to the number of adults caught. This is not to be wondered at as

one can easily miss, at the side of a stream or a rice field, many places where larvæ are living, but the village cowshed fulfils the function of a trap for the adults.

On carefully searching the sides of streams and rice fields a fair supply of anopheline larvæ were usually to be obtained in the early months of the year and until the setting in of the monsoon in June. During the continuance of the monsoon the streams were in flood and the most prolonged and careful search of their banks ever failed to reveal a single larva. After the cessation of the monsoon in October larvæ were again found at the sides of the streams and rice fields.

The tank at Koraput yielded large numbers of *A. fuliginosus* in the early months of the year when it was weedy. In the tank at Nandipur about Christmas time I found larvæ of *A. sinensis.*

The only permanent puddle I ever saw on the upper plateau was one which formed on the road near Dhooliambo at a place where the bandies turn off the road into a stand. Curiously enough in November this puddle was always swarming with *A. rossi* and culicine larvæ. As *A. rossi* was excessively rare at the time I suspect that females depositing the eggs may have come in the bandies from the plains. Captain Gill, I.M.S. (3) has drawn attention to such a method of spread of anophelines.

On a few occasions in the jungle I came across collections of water in holes in tree trunks but I never found larvæ in any of these.

Exceedingly common everywhere, throughout the whole of the Jeypore country, both in streams and rice fields was a little green striped fish, about an inch in length, which Professor B. L. Chaudhri of the Indian Museum has kindly identified for me as *Danio rerio*. This little fish goes about in small shoals and wherever it could gain access larvæ were never found. It does not follow from this that the *Danio rerio* actually devoured the larvæ. It is quite possible that other little fish were responsible for the absence of larvæ; where *Danio rerio* could find its way, other fish might find their way also.

Seasonal Variation in Anophelines on the Upper Plateau.—The great feature revealed by observing the anophelines of the 3,000 foot plateau throughout the year was not so much the variation in total numbers as the remarkable manner in which at different seasons the proportion of the different species to the whole varied.

Judging by very intimate experience, for I was almost daily collecting throughout the twelve months, anophelines were at their lowest prevalence about the early part of January. They rose somewhat in numbers until the rains set in and then diminished slightly. They maintained a fairly steady prevalence throughout June, July and August and rose again in numbers in September, reaching the maximum for the whole year in the first half of December. But as already stated I do not think the variation in the total numbers was very great.

A study of the percentage prevalence shows that the species of anophelines occurring in the Jeypore country fall into two groups as regards their seasonal prevalence. One group

consisting of *A. culicifacies* and *A. rossi* attains maximum prevalence during the rainy season and falls to a minimum or, in the case of *A. rossi*, actually disappears during the dry season. The other group consisting of *A. Jeyporiensis*, *A. listoni*, *A. maculipalpis*, *A. fuligiosus* and *A. theobaldi* behaves in a manner exactly converse to the first group, that is to say, they reach a minimum or actually disappear during the rains and attain their maximum during the dry season. I have called the first the surface water or pool breeding group and the second the stream breeding group. On the chart* is shown the rainfall, and the close relationship, the one the converse of the other, of each of the groups respectively to the rainfall, is so strikingly shown as to admit of no doubt that an intimate *causal* connexion exists.

The Lower Plateaus.

I am unable to say what the anopheline conditions are upon the lower plateaus during the actual monsoon as I did not visit these during the rains. But in June 1911, in December 1911, and in January, February, March and April 1912, anophelines were exceedingly difficult to find upon the 2,000 foot plateau as compared with the upper plateau.

The abruptness of the line of demarcation between the two areas of anopheline prevalence is remarkable. There is a village Maligura just at the foot of the Jeypore Ghat at the point where the road changes from the level to a steep incline. This village has a small water channel running through it. On January 25th at this village anophelines were collected with ease, yet on the following day at Balliagong a most prolonged search only revealed one. On February 18th at the village of Gosala a most prolonged search failed to reveal a single anopheline, but on February 19th they were found with ease at Maligura. Gosala and Balliagong are 5 or 6 miles out from the foot of the hills. On February 25th I visited Umrigaon, a large village only about two miles from the foot of the hills, and here again a search, lasting over some hours, showed not a single anopheline.

Freshness of the water of breeding places and a moist condition of the atmosphere appear to be far more essential for anophelines than they are for the commoner culicines. Freshness of the water of springs and streams and freshly fallen rainwater all appear to be favourable to anophelines. On the lower plateaus where there were streams in the jungle larvæ were, as a rule, readily found if the water was fresh and flowing. Often in the large streams on the lower plateaus during the dry season there is ample water as the villagers put bunds across the stream to retain it, but there is scarcely any flow. Under these circumstances I could never find anopheline larvæ, though culicine larvæ were often present in very large numbers.

I have already remarked that tanks on the 3,000 foot plateau are almost unknown as no necessity for them exists. On the lower plateau, however, almost every village has its tank. These tanks usually have a rocky bottom and abundant water plants. At any rate during the dry season they contain small fish. When they are very crowded with fish it is almost impossible to find larvæ.

* Not printed.

When fewer fish are present larvæ can be found in abundance in parts which are more or less cut off from the main body of water. Occasionally in small shallow tanks larvæ are readily found by wading in some distance from the margin.

The species of anopheline which was most in evidence and which appeared to thrive on the lower plateaus in June, December, January, February and March was *A. fowleri.* (Christophers.) It evidently passes its larval stage in the tanks, its larvæ probably being in some way specially adapted for life under these conditions.

Species of Anopheles.

Altogether fifteen species of anophelines have been met with in the course of the investigation. These are :—

Anopheles (Myzomyia) culicifacies. Giles.
" " *listoni.* Liston.
" " *albirostris.* Theobald.
" *(Pyretophorus) jeyporiensis.* Theobald.
" *(Nyssorhynchus) theobaldi.* Giles.
" " *fuliginosus.* Giles.
" " *jamesii.* Theobald.
" *(Nyssorhynchus) maculipalpis.* James and Liston.
" " *karwari.* James.
" *(Pseudomyzomyia) rossi.* Giles.
" *(Nyssomyzomiya) tessalatus.* Theobald.
" *(Neocellia) stephensi.* Liston.
" " *fowleri.* Christophers.
" *(Myzorhynchus) barbirostris.* Van der Wulp.
" " *sinensis.* Wiedemann.

The effect of flooding in the hill tracts.—We would not expect flooding in the Jeypore country to favour anophelines. The country has a highly absorbent soil and its configuration is admirable for drainage. On the contrary, in the Jeypore country, floods appear to be actually unfavourable to anophelines. On the upper plateau late in September there was a cyclone and close on 12 inches of rain fell in one night. Every stream was a raging torrent and many of the valleys were sheets of water. Yet in a few days all this water flowed rapidly away. Adults were much reduced in numbers for two or three days, but quickly regained their normal prevalence. Larvæ were excessively difficult to find. Up to the end of December I watched one pool left from this flood in a rice field which had been flooded and the crop destroyed. Abundant acquatic fauna appeared in the pool but only on one occasion did I see an anopheline larvæ in it. Large acquatic larvæ especially ground feeders may escape the effects of such floods while anopheline larvæ are washed away.

On the 2,000 foot plateau the same soil and almost as good facilities for drainage exist, as on the upper plateau, and we can therefore readily understand how villages near the river banks need not suffer especially from malaria, in consequence of flooding, provided the country is cleared of jungle.

We may contrast the effect of flooding as here described with that met with in the Punjab. In certain parts of the Punjab when

floods occur along the river banks much of the water does not drain away and conditions are brought about which are most favourable to anophelines.

IV.—Malaria in the Hill Tracts. The Parasite and Spleen Rate.

On the upper plateau a very high parasite rate was found. In the following table is shown the actual number of parasites enumerated in a ten minutes search of 899 blood films taken on the upper plateau at different times of the year:—

Season.	Number of persons examined.	Quartan parasites.	Benign tertian parasites.	Malignant tertian crescents.	Rings.	Total number of parasites.
February, March and April ...	385	518	276	23	3,352	4,169
May, June and July	300	251	151	63	3,920	4,385
October and December ...	214	251	339	46	3,745	4,381

Note.—In this table only large forms have been diagnosed. In the diagnoses of rings so much judgment must be exercised that when infections with more than one species of parasite are so frequent the diagnosis of rings becomes very uncertain.

In the next table the number of parasites found per hundred of films examined is shown:—

Season.	Quartan parasites.	Benign tertian parasites.	Malignant tertian crescents.	Rings.	Total number of parasites.
February, March and April.	134	72	6	871	1,083
May, June and July ...	84	50	21	1,307	1,462
October and December ...	117	158	21	1,750	2,037

The large amount of quartan met with is in marked contrast with the conditions usually found in the plains of the Punjab, where quartan is rare. Compared with the first and third period there is a decrease in the amount of quartan present in the period May, June and July. I strongly incline to the view that the species of anophelines present is one of the factors concerned, the amount of quartan varying synchronously with the rise and fall in prevalence of the stream breeding group of anophelines.

Christophers (4) puts forward the view that under conditions when anophelines are on the increase, those species of malaria parasites which most largely develop gametes will be especially

favoured. The quartan parasite is a low gamete producer as compared with the malignant tertian parasite, so when anophelines are on the increase, as they are in May, this view would account for a relative increase of the malignant tertian parasite. My figures show that such an increase does occur, and this increase would account for a relative decrease of this parasite.

In respect to the proportional prevalence of the various species of malaria parasites in the blood of any community we must not overlook the possibility of the blood of the host largely affecting the question. We shall deal later with evidence of the action of the blood of the human host in determining the number of gametes present in malignant tertian malaria and also the actual number of parasites to be found in the peripheral circulation.

In the table given below are shown the villages examined, the number of children found infected and the average number of parasites, not for each of the infected children, but per child for each village :—

Villages.	Month.	Number of children examined.	Number of children infected.	Average number of parasites found in unit time per child.
Koomba	February	44	21	2·3
,,	May	39	28	4·9
,,	July	23	16	11·9
,,	October	59	47	13·3
Old Koraput	March	21	17	12·9
,,	May	18	13	12·9
,,	June	28	23	19·5
,,	October	10	7	9·7
Chindrigaon	February	45	35	13·8
,,	May	46	35	14·6
,,	July	14	10	15·6
,,	October	33	27	12·4
Deola	March	45	27	5·9
,,	June	42	24	9·0
,,	December	44	30	11·5
Ranigedda and Guma.	June	85	62	8·8
,,	December	46	43	24·8
Maligraon, Kaniput, Pujariput, and Janigur.	February	63	43	12·2
Lundigura	March	20	11	6·8
Fottenghi	April	42	32	7·9
Champaguda	May	29	20	14·0
Manohar	June	32	24	12·5
Jayanagar	June	47	22	3·7

Childrigaon and Old Koraput are situated amongst a tangle of low hills and watercourses. Koomba is in a far more open situation. All three villages have the same classes of inhabitants, are at the same altitude, and subject to identical climatic conditions. Any variation in the intensity of malaria must reflect the influence of their immediate physical environment. It was difficult to estimate the relative numbers of adult anophelines in these villages with any approach to accuracy, but during the dry season it was always distinctly more difficult to find anophelines in Koomba than

in Old Koraput and Chindrigaon. As the season progressed and the rains became established the parasite rate of Koomba increased to equal that of the other two villages.

The spleen rates of Koomba and of Chindrigaon are identical, the actual figures being for the former 81·5 per cent calculated on 176 children, and for the latter 81·3 per cent calculated on 246 children. For the spleen rate to be identical despite considerable divergence in the parasite rate implies that very great differences in the parasite rate must probably exist before the spleen rate shows any difference.

On the 3,000 foot plateau observation of anophelines and of the spleen rate failed, to disclose any marked variation in the distribution or intensity of malaria. Only by recourse to the far more delicate test of parasite enumeration was there secured any tangible evidence of variation in the intensity of malaria in the different villages.

On the 2,000 foot plateau, though we still find in the majority of villages examined an excessively high spleen rate to be the rule, yet by a reference to the subjoined table we see that some of the villages stand out as exceptions with spleen rates much below the average for the upper plateau.

Village.	Number of children examined.	Spleen rate.
Jayanagar	46	43 per cent.
Gosala	95	42 "
Amligaon	149	37 "
Barabankali	43	23 "

As regards the nature of their inhabitants these villages differ in no way from other villages on the 2,000 foot plateau which have high spleen rates. All the four villages given in the table are situated in areas which have, by common repute, greatly improved in salubrity within the last 20 or 30 years and in areas in which, during that period, the reduction of jungle and its replacement by rice cultivation has been enormous. Of the four villages Gosala is close to the Kolab River and Barabankali and Amligaon to the Indravati River. Jayanagar is, however, close to the great tank or lake at Jeypore and has a great deal of swampy ground near it.

There can be no question after studying what has been written in past years of malaria in the neighbourhood of Jeypore Town that this place has vastly improved in salubrity. Amongst the tahsildars and their staffs it is now regarded as the best of the stations in the Jeypore country and as infinitely preferable to any of the taluk headquarters on the upper plateau. As nothing has been done directly to improve the malariousness of the town, we are forced to the conclusion that the decrease of malariousness and the comparatively moderate spleen rates of some of the villages nearby have resulted from the one great change known to have occurred, viz., the great extension of rice cultivation and the concomitant disappearance of much of the jungle.

It might be thought that the cultivation of rice under these circumstances would favour anophelines greatly, but the explanation probably is, that the little squares in which the paddy is grown, being all of them prepared and levelled with great care, remain full of water which by reason of its permanence during rice growth supports an abundant predaceous fauna. Probably an even more potent reason lies in the fact that only during the actual rainy reason is the ground moist. Immediately the crop has been cleared the ground dries rapidly and becomes caked and hard. Jungle retains the rainfall and keeps the soil in a moist condition long after the rains have ceased.

On the 1,000 foot or Malkangiri plateau we again find a uniformly very high spleen rate.

Below are given the density of population and the spleen rate average of a number of villages of the 3,000-foot plateau, the 2,000-foot plateau and the Malkangiri plateau.

Plateau.	Population per square mile.	Number of children examined.	Spleen rate.
3,000-foot	78	2,278	89·1
2,000 "	74	2,561	69·9
Malkangiri	15	851	90·7

On the Malkangiri plateau we would not expect so sparse a population to effect much clearing and we find a maximum spleen rate. On the 3,000-foot plateau we may surmise that jungle clearance has not affected the spleen rate owing to the stream system conditions. If I had only compared the 3,000-foot with the 2,000-foot plateau I might have been led to ascribe the lower spleen rate of the latter to the fundamentally different conditions appertaining to anophelines in the two areas. But the difficulty experienced in finding anophelines in villages on the 2,000-foot plateau is experienced in equal degree in the Malkangiri plateau where the spleen rate is as high as on the upper plateau. The great and obvious difference between these two areas lies in the vastly denser population of the former and the amount of clearing which has been on this account effected. I, therefore, attribute the smaller spleen rate of parts of the 2,000 plateau to clearance of jungle.

There is no doubt a very considerable difference in the climatic conditions of the plateaus, the lower plateau being more hot and humid than the upper, but this clearly does not determine the intensity of malaria. On the same plateau we have spleen rates varying from as low as 23 per cent at Barabankali to as high as 95 per cent at Jatabal. We are, therefore, justified in concluding that the factor which leads to a lower spleen rate is one of irregular distribution, and such a factor constantly associated with a low rate is extensive rice cultivation and clearance of jungle.

V.—IMMUNITY AND THE SPLEEN RATE IN THE HILL TRACTS.

The fact that the aborigines of the Jeypore country have in childhood a spleen rate of 80 per cent to 90 per cent and a parasite rate (as shown by a ten minutes examination) of 80 per cent has not the slightest effect on the physique to which they subsequently attain. The children do look as if they might be better nourished and more clothed with flesh, but whether their appearance is due to the effects of malaria or is merely the effect of their general conditions of life I cannot say. The physique of the adults both men and women is splendid.

If a European were to go and live in one of these villages amongst these people, without medical treatment and without protection from mosquitos his health would rapidly be shattered and he could scarcely hope to be alive at the end of two years. If we bear this in mind we shall realize at once the reality of immunity in malaria. The aborigine harbours large numbers of the malaria parasite in his blood when in childhood but is in a high degree tolerant of its presence and immune to its effects.

There are no statistics regarding the birth and death-rate of these people, though I am convinced they have a high birth-rate. Of their death-rate I could form no opinion and could get no evidence that it was affected by malaria.

As I have said elsewhere the Dombos are far inferior in physique to the Khonds, Porajas and Gadabas. They suffer more from fever, but even they do not suffer very much. I had several Dombos as servants throughout the time I was in the country, but on no occasion did any of them miss a day's work.

I frequently saw children four or five years old or more with high temperatures wandering about the village. They usually seemed inclined to take things quietly but did not appear to desire to lie down. But the missionaries informed me that the small children of the aborigines sometimes suffer for weeks on end with continuous fever.

More definite information regarding immunity was obtained from the *spleen composition.*

For recording the degree of enlargement of the spleen five classes have been made use of. All spleens from those just palpable to those reaching one finger's breadth from the costal margin form class 1. The space between a line one finger's breadth from the costal margin and the umbilicus is divided into three equal portions which form respectively, the limits of classes 2, 3 and 4. All spleens reaching beyond the umbilicus, i.e., beyond either a vertical or horizontal line passing through it are placed in class 5.

When the spleen composition of the various castes and tribes are graphically represented, persons *under* and *over* 16 years of age being dealt with separately, we see that these fall into three well characterized groups.

One group includes the Porojas, Gadabas, Khonds, Omanaitos, Bhottras and Bhumias. The type of spleen rate characteristic of this group may be looked upon as the immune or true aboriginal type of spleen rate.

Another group comprises the Kapus, Telugus, and Rellius. The type of spleen rate here may be regarded as the non-immune or immigrant spleen rate.

The Dombos, Gourias, Ghasis, Ronas Paiks and Sundis fall into a third group, the type of spleen rate of which is intermediate between those of the other two groups.

Comparing the aboriginal type of spleen rate with the immigrant type of spleen rate we see that they differ in two well marked features. In the former as compared with the latter the larger sizes of spleen are very poorly represented and the spleen rate of persons over 16 years of age is very low. In regard to both these features the spleen composition of the partially acclimatised group occupies an intermediate position. It is of interest to note that, had we confined our observations of the spleen rate to persons under 16 years of age, one of the most striking features in which these types of spleen rate differ would have been overlooked.

When the spleen composition is examined in relation to both age and sex the following results are obtained:—

Age in years.	1 to 2	3 to 5	6 to 10	11 to 15	16 to 20	21 to 25	26 to 50
No. of males examined.	426	564	1,192	998	1,118	534	779
Spleen rate ...	77·94	87·94	85·07	82·57	50·63	46·25	39·54
No. of females examined.	453	444	856	757	1,110	273	521
Spleen rate ...	70·64	82·66	86·33	82·30	49·10	51·28	40·12

From six years of age onwards the spleen rates in the two sexes are for all practical purposes absolutely equal. But we find evidence of a difference in the spleen rates of male and female in children under six years of age. The following table and the note upon it have been drawn up by Mr. Greenwood of the Lister Institute :—

Age in years.	Difference between the percentages.	Probable error of difference.	Ratio of difference to its probable error.
1–2	7·30	1·98	3·69
3–5	5·28	1·52	3·47
6–10	1·26	1·05	1·2
11–15	·27	1·24	·22
16–20	1·53	1·01	1·51
21–25	5·03	2·51	2·00
26–50	·58	1·87	·31

"If there be no sexual difference, the entries in column 2 should be zero or only differ from zero by amounts which could reasonably be attributed to errors of sampling.

The odds against samples of the given sizes drawn from the same 'population' differing by 3·69 or 3·47, the respective probable errors are approximately 77 to 1 and 51 to 1.

The odds against the largest of the other deviations (21 to 25) are only 4·6 to 1.

It seems reasonable to suppose that the deviation in the first two groups are not merely due to errors of sampling."

VI.—IMMUNITY AND THE PARASITE RATE IN THE HILL TRACTS.

The table below shows the frequency with which quartan forms, benign tertian forms and crescent forms were detected in the blood films examined. Rings are left undiagnosed as there is considerable chance of error when identifying the parasite from ring forms only.

No. of blood films examined.	No. infected.	No. infected with quartan.	No. infected with benign tertian.	No. infected with crescents.	No. showing rings only.	Mixed infections.
949	639 67 per cent.	184 19 per cent.	163 17 per cent.	59 6 per cent.	314 33 per cent.	76 8 per cent.

With the aid of this table we are able to judge whether or not infection with one species of the parasite is unfavourable to infection with other species of the parasite.

Out of 184 films containing the quartan parasite 59 or 32 per cent showed other species of the parasite also. Looking at the table we should expect at the most about 17 per cent benign tertian plus about 6 per cent crescents, that is to say, about 23 per cent of other infections.

Out of 163 films which contained the benign tertian parasite 70 or 42 per cent showed other infections. We should from our table have expected at the most about 19 per cent of quartan plus about 6 per cent of crescents, that is about 25 per cent of other infections.

Out of 59 blood films containing crescents 28 or 47 per cent showed other infections. We should have expected at the most about 19 per cent of quartan plus about 17 per cent of benign tertian, that is to say, about 36 per cent of other infections.

We have therefore no evidence that the presence of one species of parasite in the blood is unfavourable to the presence of other species.

93 films which showed *only benign tertian* parasites contained :—

Amœboid and mature form of Benign Tertian.	Rings.
449	1,073

Ratio 1 to 2·3.

125 films which showed *quartan parasites only* contained :—

Typical quartan forms.	Rings.
778	2,059

Ratio 1 to 2·6.

31 films which showed crescents of *malignant tertian* and rings only contained :—

Crescents.	Rings.
54	327

Ratio 1 to 6.

314 films which showed rings only, contained 3,865 rings.

The steady manner in which the parasites present in the peripheral blood decrease from infancy to the age of puberty is well shown in the following table :—

Age.	Number of persons examined.	Percentage of persons infected.	Total number of parasites seen.	Average number of parasites seen per person examined.	Average number of parasites seen per infected person.
		PER CENT.			
1 to 5	205	81·5	5,400	26·4	32·1
6 to 10	347	68·0	4,369	12·6	18·8
11 to 15	228	58·8	1,370	6·0	10·2
16 and over ...	67	38·8	464	7·0	17·8

Among the aborigines of the Jeypore country the percentage of children showing crescents, in proportion to the percentage of the children showing parasites is phenomenally low, when compared with the corresponding figures for the people of the Punjab.

In the Punjab I (5) have shown that with a parasite rate of 75 per cent we may get a crescent rate of 25 per cent, but in the Jeypore country with a parasite rate of 70 per cent we get a crescent rate of only 6 per cent.

This might be accounted for by the fact that quartan is very common in the Jeypore country and rare in the Punjab. But the prevalence of quartan would not in any way account for the fact, that in Jeypore when crescents were present in a blood they were scanty as compared with the crescent containing bloods of the Punjab. I was at first inclined to think, that, because crescents were not much in evidence in the Jeypore country as compared with the Punjab, therefore malignant tertian was far less common in the former than in the latter.

Parasites calculated per 100 *inhabitants of the* 3,000-*foot plateau at three different seasons (each ten minutes count).*

Season.	Quartan parasites.	Benign tertian parasites.	Malignant tertian crescents.	Rings.	Total.
February, March and April ...	134	72	6	871	1,083
May, June and July	84	50	21	1,307	1,462
October and December	117	158	21	1,750	2,037

In the table given above it will be seen that, although both quartan and benign tertian parasites show an actual decrease in numbers in the period May, June and July as compared with the numbers for February, March and April, nevertheless the number of ring forms has increased very considerably. I attribute the whole of this increase to a rise in the prevalence of malignant tertian parasites.

I believe the condition really is that, in the Jeypore country, malignant tertian is fairly common but crescent formation is by some means checked.

In my ten minute counts I cover some 250 to 350 fields and amongst 949 bloods so examined I only once counted 18 crescents in one film.

The average number of crescents in a film infected with them was only 2·08. One hundred and twenty-three was the total number of crescents seen while searching 949 blood films. Any one with experience of malaria in the Punjab will admit that this was an exceptionally low figure.

The extraordinary rarity of crescents in the blood of Dombos is most remarkable. One hundred and eighteen Dombo children with a parasite rate of 51·4 per cent only showed crescents in three persons and even then only one crescent in each. In 288 Porojas there were seen 79 crescents. For the 118 Dombos to have had crescents even in this low proportion they should have had 32 crescents or 10 times as many as they did have. When we bear in mind that in estimating the number of crescents present in a blood a plan commonly adopted is that of comparing them in numbers with the leucocytes present, and that cases have been described in which the number of crescents present is equal to the number of leucocytes, we see at once how phenomenal is this scarcity of crescents in the blood of the inhabitants of the Jeypore country.

I am informed by Sir Ronald Ross that this paucity of crescents in the blood of the aborigines of an intensely malarious country is a phenomenon met with in other parts of the world.

I have elsewhere given reasons for assuming that the Dombos are, as compared with the Porojas and other aboriginal tribes, of recent introduction to the country.

When we compare the parasite rate amongst Porojas and Dombos, living in the same villages under identical conditions, we see at once that there exists a very remarkable difference in the frequency with which the parasite is present in their peripheral circulation.

In order to compare the character of their respective parasite rates I have selected Porojas and Dombos living together in the same villages and exposed to identical conditions. For this purpose there are available blood films from 244 Porojas and 115 Dombos, all of whom were 16 years of age or under:—

Parasite rates of Porojas and Dombos.

Tribe.	Season.	Number of children 16 years and under examined.	Average age.	Percentage infected.	Average number of parasites per child examined.
				PER CENT.	
Porojas ...	March and April	68	6·3	77·9	9·6
Dombos ..	Ditto ...	36	8·3	50.0	2·9
Porojas ...	May, June and July ...	95	9·5	78·9	15·1
Dombos...	Ditto ...	46	8·5	47·8	5·9
Porojas ...	October and December ...	81	10·4	79·0	20·9
Dombos...	Ditto ...	33	9·7	60·0	6·1

Total for all three periods.

Tribe.	Number of children 16 years of age and under examined.	Average age.	Percentage infected.	Average number of parasites per child examined.
			PER CENT.	
Porojas	244	8·9	78·7	15·5
Dombos	115	8·7	51·4	5·0

The Dombos have a higher spleen rate than the Porojas as will be seen by comparing the spleen rates of adults of both tribes. The Dombos are also said to suffer (clinically) more from malaria than do the Porojas. Yet they show fewer parasites in their circulation.

If we compare the species of parasites, found in their bloods respectively, we find that the proportions in which the various species are present are much the same in both, except, that, as remarked elsewhere, crescents are fewer in the blood of the Dombos.

Poroja and Dombo parasite rates.

Tribe.	Number of children examined.	Average age.	Quartan forms.	Benign tertian forms.	Malignant tertian crescents.	Rings.	Total parasties.
Porojas ...	228	8·87	482	238	79	4,076	4,875
Dombos...	118	8·66	79	27	3	480	589

From the above table we can calculate an average parasite content for a single Poroja and Dombo blood film.

Average content of blood film.

Tribe.	Average age.	Quartan forms.	Benign tertain forms.	Malignant tertian crescent.	Rings.	Total parasites.
Poroja ...	8·87	1·67	0·83	0·27	14·15	16·93
Dombo ...	8·66	0·67	0·23	0·03	4·07	4·99

If now we multiply the figures, relating to parasites in the lower row, by 3·3 we get a fair approximation to the figures in the upper row, except in the case of malignant tertian crescents.

In considering the relationship of the host and the parasite one to the other it must be borne in mind that we have at least two factors at work.

(*a*) An adaptation of the host to the parasite.
(*b*) An adaptation of the parasite to the host.

It is very important that we should not, in concentrating our studies on the first of these factors, overlook the great importance of the second.

The different proportions of the crescent forms of malignant tertian malaria and the differences in the numbers of all three species of the parasites of malaria which appear in the circulation of different races of man, when exposed to infection with the same races of the parasite, are possibly, in part at any rate, evidence of the adaptation of the parasite to the host. In the tolerance and immunity of the Poroja to the parasite and in the larger numbers which he harbours in his circulation we see evidence of harmonious relations which possibly became fully established many thousands of years ago. Whatever may have been the nature of the conflict between host and parasite long ages ago, a compact appears to have been agreed upon, a *modus vivendi* established, and a condition of equilibrium now prevails.

The type of fever contracted by immigrants to the Jeypore country appears to be of very great severity. We can put forward at least three possible explanations of the severity of the fever.

(*a*) Simultaneous infection by a considerable number of infected anophelines.
(*b*) Inoculation by very heavily infected anophelines.
(*c*) A high degree of virulence of the parasite.

VII.—The Zygote and Sporozoite Rate.

In the following table are given details of the mid-gut and salivary glands of anophelines taken on the 3,000 foot plateau, examined for the presence respectively of zygotes and sporozoites.

Mosquitos examined for zygotes and sporozoites.

Species.	Month.	Stomachs examined.	Number infected.	Salivary glands examined.	Number infected.
A. culicifacies	March, April, and May.	72	*Nil.*	75[1]	*Nil.*
A. listoni	,,	1	*Nil.*	10	*Nil.*
A. jeyporiensis	,,	29	*Nil.*	66	*Nil.*
A. fuliginosus	,,	4	*Nil.*	10	*Nil.*
A. maculipalpis ...	,,	9	*Nil.*	15	*Nil.*
A. theobaldi	,,	1	*Nil.*	1	*Nil.*
A. culicifacies	June, July, and August.	284	*Nil.*	147	*Nil.*
A. listoni	,,	34	*Nil.*	29	*Nil.*
A. jeyporiensis	,,	4	*Nil.*	1	*Nil.*
A. fuliginosus	,,	4	*Nil.*	3	*Nil.*
A. maculipalpis ...	,,	3	*Nil.*	4	*Nil.*
A. culicifacies	Sep., Oct., and Nov.	3	*Nil.*	57	*Nil.*
A. listoni	,,	17	*Nil.*	229	4
A. jeyporiensis	,,	28	*Nil.*	335	*Nil.*
TOTAL ...	...	493	*Nil.*	982	4

Owing to the extraordinary difficulty experienced in finding infected anophelines I sought to determine some means of differentiating old from young anophelines, and as a result came to the conclusion that the more threadbare the condition of the wing of an anopheline, the older it is and the more likely to contain sporozoites (see Paludism No. 5, September 1912, pp. 33 to 37, or Tropical Diseases, Bulletin, Volume 1, No. 3, 1912).

Although the method of selecting the oldest anophelines found should help us greatly in finding sporozoites, we are still at a loss to explain the fact that zygotes are equally difficult to find. Much light remains to be thrown on this subject. The difficulty is one that is being frequently encountered by other observers.

There is some ground for suspecting that *A. listoni* seek more for human blood than for that of cattle.

For instance, between August 24th and September 8th, mosquitos were collected daily in two places, namely, a cowshed in Chindrigaon village and a large hut used by the female orphans of the Koraput Mission. These two places are within half a mile of one another on opposite sides of a small valley much broken up by streams.

From the thatch and walls of the cowshed the mosquitos were collected in test tubes by myself from about 9 to 10 a.m. From the orphanage hut the children collected them from the inner side of a wire gauze window as the insects were endeavouring to get out in the mornings and evenings.

The details of the two catches are as follows :—

Cowshed.	Females.	Males.	Orphanage hut.	Females.
A. listoni ...	87	1	A. listoni	87
A. culicifacies	1,949	196	A. culicifacies	8
A. rossi	105	19	A. rossi	1
A. jeyporiensis	24	...	A. jeyporiensis	3
A. fuliginosus	1	...	A. fuliginosus	1
A. theobaldi	1	...	A. maculipalpis	1
Culex	6	...	Stegomyia	1

Here the relatively great preponderance of *A. listoni* in the catch made in the room where the children slept is most remarkable. In villages in the neighbourhood of Dhooliambo a similar marked preponderance of *A. listoni* in batches of mosquitos from dwelling rooms was recorded in September.

Between October 7th and 30th the following was the composition of the catch from dwelling rooms in Kontaguda village :—

	Females.	Males.
A. listoni	237	1
A. jeyporiensis	112	...
A. culicifacies	35	1
A. rossi	4	1
A. fowleri	5	...
A. punctulata	2	...
A. maculipalpis	10	...
A. jamesii	1	...
A. karwari	1	...
A. theobaldi	2	...
A. barbirostris	1	...
Culex	1	...

In this dwelling room there was a great prepondence of *A. listoni.*

In the same neighbourhood the following were taken from a cowshed in another village (Kuntagaon) on October 12th :—

	Females.	Males.
A. culicifacies	23	1
A. jeyporiensis	11	...
A. rossi	1	...

Here there were no *A. listoni* at all.

Again on two dates October 15th and October 30th from a cowshed in Kakanambo village the following were taken :—

	Females.
A. jeyporiensis	8
A. listoni	1
A. culicifacies	4
A. theobaldi	1
A. rossi	1

Collecting from dwelling rooms in the same village on October 21st, 29 female anophelines were taken, all of which were *A. listoni.* In view of the above it is of interest that the only species of

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anopheline, in which I succeeded in finding sporozoites in the salivary glands, was *A. listoni.*

The habit of *A. listoni* of biting human beings by day is of interest. In the Jeypore country *A. listoni* had this habit.

VIII.—THE NATURE OF ANTI-MALARIAL WORK SUITED TO THE HILL TRACTS.

It is of more value, after having rendered clear to the administrator the mode of action of a certain biological factor, to indicate to him the lines along which his own activities can or may affect that factor, than it is to place before him a set series of recommendations.

It is no exaggeration to say that, to those who have knowledge or experience of the Jeypore Hills, to think of those hills is to think of *malaria.*

So large does the problem of malaria loom in that country, it is fitting that all those, who are in any way responsible for the administration of the same, should be in possession of as clear information, of the workings of malaria in that country, as we can place before them.

We have here a country intensely malarious throughout but divided physically into two distinct areas.

There is the upper plateau with its system of hills and streams with a supply of stream water so constant as not only to enable wet cultivation to be carried on throughout the twelve months, but also to ensure an unfailing supply of anophelines, for the carriage of malaria, over the whole of the same period.

There are the lower plateaus largely lacking in these features where wet cultivation is possible during the rainy season only, while at other seasons a condition of dessication tends to prevail, which condition of dessication so unfavourable to anophelines is greatly exaggerated by the clearance of jungle and the substitution of rice cultivation.

On the upper plateau as nothing that we can do can influence the rainfall or affect the perennial flow of the streams, we cannot hope directly, by any means at present in our power, to affect materially the prevalence of anophelines.

On the other hand, the upper plateau offers a splendid field of scope for that policy, which for years has been so worthy a tradition of the Madras Government, namely, the preservation and protection of the primitive aboriginal races. These tribes who, living surrounded by anophelines as they do, harbour malaria parasites in large numbers in their blood, have, nevertheless, in the course of long ages, been endowed by nature with a high degree of tolerance of the parasite and a remarkable immunity to its effects.

Protected from the rapacity and oppression of those who, as in every country are ever ready to exploit such simple and primitive people, the aborigines must become more and more settled and gradually bring under cultivation the maximum area of country capable of it.

This in itself cannot fail in great measure to reduce its malariousness both by raising the stamina of the people and by decreasing the amount of waste stream water.

The Madras Government in placing these aboriginal tribes under the care of an agent, with special and largely discretionary powers, have adopted a policy which is not only elastic and well adjusted to local administrative requirements, but is also well calculated to aid nature in the efforts she is making to endow these tribes with power to rise superior to their malarious surroundings.

It is so very largely true that malaria is a disease of waste water, waste land, and waste people, that the administrator, who might feel disheartened at the remoteness of the prospect of being able directly to influence the anophelines and the malaria of such a country, may well take courage from the thought that by patient, just, and careful administration he may yet indirectly reduce them in a degree far beyond his conception.

When we leave the upper plateau and descend to the lower plateaus we have to deal with entirely different circumstances. This is a country of an altogether different physical aspect and nature which has been rightly described as one "crying out for development." Here we find anophelines and malaria also and the latter moreover in a terrible degree of intensity.

But while the upper plateau may be described fitly as the happy home of anophelines, on these lower plateaus we find that anophelines are far from happy and are obviously struggling against difficulties, and it is in our power to add to their difficulties by clearing away, almost their sole remaining refuge here, the jungle, and by draining and dessicating the face of the country so laid bare by extensive and efficient cultivation.

Over tracts of this country, and such tracts are vast, which have a fairly even surface and an excellent slope for drainage towards the great and deeply cutting streams, we are justified in confidently anticipating that, by the measures described above, we shall in so far reduce the prevalence of anophelines, as to enable the immigrant to live in the country in freedom from malaria. But the clearing and cultivation of such tracts must be complete.

In many places on the two lower plateaus there is a type of cultivation which must be pernicious in the extreme, namely, the cultivation of glades or narrow strips of land running through the jungle. It would seem that such a system of clearing the land must result in the maximum of cultivation that it is possible to combine with the minimum of reduction of malaria. This style of cultivation is much in evidence in the Malkangiri taluk.

There need be no fear that by extensively clearing and cultivating these lower plateaus, the adequate conservation of forest will be in any way endangered. Despite the large extent of the areas conserved as forest, but little is to be seen in the country that is really worthy of the name of timber. Many of the areas that are reserved appear to be so reserved in order to secure the collection of grazing fees, but it would seem that such land when brought under cultivation would yield a far higher revenue.

No matter how much benefit there is to be accomplished by the clearing of jungle there yet remain vast unpopulated tracts where such clearing is not indicated, at any rate, as far as the reduction of malaria is concerned.

On the slopes of the Ghats, and in the wide belt of broken country between Kolar and Govindapili, through which the road descends from the Jeypore to the Malkangiri plateau, but little good could be accomplished by deforestation. Under the circumstances such tracts are pre-eminently indicated for utilisation as forest reserves. But the reservation for forest of any areas in the neighbourhood of villages, which areas if not so reserved could be cleared and brought under cultivation, is most strongly contraindicated.

We may predict with confidence that every furlong of road, every arch of culvert, every span of bridge that is built on the Jeypore plateau will do its share of silent service in the great work of converting vast wastes of malarious jungle into populous, healthy, and fertile land.

The rise in the price of food-stuffs which is occurring throughout the world is creating in the minds of many grave concern and misgiving. Yet by those, who see clearly the great part which hygiene has played and will play in the evolution of the human race, that rise in prices is regarded as a potent factor in the reclamation of the waste places of the world from the tyranny of want and disease.

The lower plateaus of the Jeypore country show promise for vast improvement and development. But the approach to the plateaus from the plains of Vizagapatam will always lie across the intensely malarious 3,000 foot plateau.

There is a fine road from Salur on the Vizagapatam side right away through to Jeypore. To encourage and develop in every way the rapidity and efficiency of transit along this route will always be sound policy as regards malaria.

IX.—PRESERVATION OF THE HEALTH OF EUROPEANS AND OTHER STRANGERS RESIDENT IN THE HILL TRACTS.

For the conservation of the health of the administrative staff much would be accomplished by locating them, as far as possible, in sites which are already proved to be healthy.

The spleen rate of the villages in a neighbourhood must be the most certain indication, ready to hand, of the malariousness of any site.

At some of the halting places the rest-houses, which are merely mud sheds with thatched roofs, must function most efficiently as sporozoite traps. These are the halting places which happen to be at some distance from any village. The aborigines using the road, having no other place handy to rest at, make use of the verandah of the rest-house. In this way a supply of infected anophelines would appear to be ensured. The provision in these cases of some sort of serai, at a distance from the rest-house, seems to be indicated.

The writer cannot too strongly urge upon all officers, serving in the Jeypore country, the immense importance of perseveringly practising every measure of personal prophylaxis against the bites of anophelines.

Serving in the Jeypore country is like serving in a hostile country where the enemy have untold reserves of ammunition, but a limited number of rifles. In the Jeypore country the supply of ammunition in the shape of parasites of a deadly type in the blood of the aborigines is practically unlimited, but *the supply of rifles in the guise of anophelines is distinctly limited.*

It is on account of the *comparative scarcity* of anophelines that methods of personal prophylaxis against them are rewarded with so large a measure of success. The writer speaks from experience as he spent sixteen months on end in the country but never once contracted malaria whilst there.

The most scrupulous care and attention should be bestowed upon mosquito nets. New ones should always be kept in reserve. They should be of a fine mesh but large in size. Portable frames for supporting large size of mosquito nets are easily made from thin bamboo. A good plan is to get a large quantity of iron rod not quite so thick as a lead pencil. Get a blacksmith to cut this into lengths of about 2½ feet and to bend each at a right angle at the middle. Three of these angle pieces bound together with wire-string, or jungle fibre make excellent supports on which to bind the angles of the bamboo frames for large mosquito nets. The arrangement is cheap and fool proof and there are no screws or small parts to get lost.

The lower margins of mosquito nets should always have about 18 inches of stout unbleached calico sewn on. Remember that if during sleep any part of the body comes against the net a mosquito can easily bite it. On getting inside a net search it most carefully for mosquitos. As mosquitos bite mostly between sunset and sunrise, it is best to arrange work and meals so as to retire early and rise at dawn. After sunset thick loose flannel trousers should be worn over an easy fitting pair of Wellington boots.

For persons settled in one place for any length of time the efficient protection of the house by wire gauze is most important. Some of the ladies of the mission who live in well-protected houses have escaped fever for several years on end.

The missionaries have a really dangerous practice of sometimes occupying when on tour the catechist's quarters in the villages. This is a risk neither fair to themselves personally nor advantageous to the magnificent work they are so successfully carrying on. A far safer plan would be to carry a tent whenever possible and pitch it some way from the village.

For persons living in the Jeypore country next in importance to prophylaxis against the bites of mosquitos comes the subject of the treatment of an attack of the disease with quinine.

The Panama Canal Zone is a country where as in the Jeypore country malaria is severe and blackwater fever is of frequent occurrence. The Department of Sanitation of the Isthmian Canal Commission commenced two years ago an enquiry into the

question of relapses in malaria. Dr. W. N. James and Dr. W. E. Deeks of the Ancon Hospital have come now to two most important conclusions :—

(*a*) That the longer the parasite of malaria remains in the human body the more difficult becomes the task of killing it with quinine. Therefore, immediate and thorough treatment of every fresh attack of fever is of great importance.

(*b*) That to effectually cure an attack of malaria, that is to say, to kill all the parasites that are in the system and leave none to produce a subsequent relapse, daily doses of 45 grains of the sulphate of quinine must be given in three separate doses during the course of the day of 15 grains each.

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Mr. Greenwood of the staff of the Lister Institute has kindly examined and discussed the statistics relating to the difference in the male and female spleen rate, and his note thereon is reproduced in this report.

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